UNCLASSIFIED
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(2)

AD-A153 082

REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

1. REPORT NUMBER: TOP 3-2-823	2. GOVT ACCESSION NO.
	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle): US ARMY TEST AND EVALUATION COMMAND TEST OPERATIONS PROCEDURE "RANGE FIRING OF CLOSE SUPPORT ROCKETS AND MISSILES"	5. TYPE OF REPORT & PERIOD COVERED: Final
	6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s)	8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS: US ARMY COMBAT SYSTEMS TEST ACTIVITY (STECS-AD-A) ABERDEEN PROVING GROUND, MARYLAND 21005-5059	10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS: AMCR-R 310-6
11. CONTROLLING OFFICE NAME AND ADDRESS: US ARMY TEST AND EVALUATION COMMAND (AMSTE-AD-M) ABERDEEN PROVING GROUND, MARYLAND 21005-5055	12. REPORT DATE: 15 March 1985
	13. NUMBER OF PAGES
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office)	15. SECURITY CLASS. (of this report): Unclassified
	15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release; distribution unlimited.

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Close support rockets and missiles
Fin-stabilized rockets and missiles
Ground-to-ground firings
Range firings

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

Provides procedures for evaluating technical performance of close support rockets and missiles through range firings. Includes guidance for ground-to-ground firings of fin-stabilized and some spin-stabilized rockets and missiles.

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US ARMY TEST AND EVALUATION COMMAND
TEST OPERATIONS PROCEDURE

AMSTE-RP-702-102
*Test Operations Procedure 3-2-823 15 March 1985
AD No.

RANGE FIRING OF CLOSE SUPPORT ROCKETS AND MISSILES

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1. SCOPE. This TOP provides procedures for evaluating the technical performance of close support rockets and missiles through range firings. This TOP also provides guidance for ground-to-ground firings of fin-stabilized and some spin-stabilized rockets and missiles.

Because close support rockets and missiles are jet-propelled for some time after launch, their flight characteristics differ from those of artillery projectiles, and correspondingly different range firing procedures are required. After launch, rockets and missiles are subject to accelerations perpendicular to the direction of motion, caused by yawing and asymmetrical thrust phenomena. Thus, throughout the burning period, the rocket may be pushed perpendicular to its trajectory as well as along it. The net effect is an increased dispersion in travel direction at burnout (as compared with artillery projectiles), a corresponding increase in impact dispersion, and diminished accuracy. In the case of missiles, there is the added possibility that on-board components such as gyros, attitude control systems, may malfunction.

Due to the variety of launch conditions, propulsion characteristics, range and accuracy, etc., among close support rockets and missiles, the sample size and data requirements will vary for each test. The project engineer must therefore determine the sample size for the specific test based on system complexities, performance, and cost. Restrictions in the sample size due to prohibitive costs of the test item may be somewhat off-set by increasing the amount of instrumentation used during the range firing test.

*This TOP supersedes MTP 3-2-823 dated 25 January 1967.

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2. FACILITIES AND INSTRUMENTATION.

2.1 Facilities.

ITEM	REQUIREMENT
Temperature-conditioning chambers	
Reference markers	semi-permanent markings
Helicopter	fitted with aerial camera with timing capability
Meteorological support facility	
Rocket/missile launcher	
Photographic equipment	see MTP 4-2-816[1]*

2.2 Instrumentation.

ITEM	MAXIMUM PERMISSIBLE ERROR OF MEASUREMENT**
Surveyor's transit	
Theodolites	$\pm$1 second
Calibrated gunner's quadrant	$\pm$0.4 mil
Doppler velocimeter	$\pm$0.1%
Range time code generator	
Doppler radar van	
Electrical sequencer	
Clinometers	
Gages and measuring devices (MTP 3-2-801 and TOP 3-2-802[2-3])	

3. REQUIRED TEST CONDITIONS.

3.1 Test Preparation.

a. Select a suitable firing site based on the size, range, and motor burnout characteristics of the item being tested. Select photographic instrumentation as necessary to obtain the required data.

b. Select test equipment having an accuracy consistent with precison of the function to be measured.

c. Ensure that all test personnel are familiar with operating characteristics of the test item.

d. Review all instructional material issued with the test item by the manufacturer, contractor, or Government, as well as reports of previous similar tests conducted on the same type of test item; familiarize all test personnel with the contents of such documents. Keep these documents readily available for reference.

*Footnote numbers correspond to reference numbers in Appendix A.

**Values can be assumed to represent $\pm$ 2 SD; thus, the stated tolerances should not be exceeded in more than 1 measurement of 20.

e. Prepare record forms for systematic data entry, test chronology, and analysis in the final evaluation of the test item.

f. Prepare adequate safety precautions to provide safety for personnel and equipment, and ensure that all SOP's are observed throughout testing.

g. Select a serviceable launcher for use in the firing test. If the launcher is a tube, stargage the tube before and after the firing test in accordance with MTP 3-2-801.

NOTES: 1) If, during any phase of testing, unexpected or unexplained test sample dispersion is noted, stargage the tube launcher again. 2) When firing ripples of rockets from a multiple-tube launcher, stargage all tubes and determine the alignment of the tubes in the cluster in accordance with TOP 3-2-802 before and after the range firing test.

h. Measure the launcher tube length, and determine the condition of the launcher tube bores in accordance with TOP 3-2-802.

i. Determine the instrumentation requirements for acquisition of range firing data. Three primary types of instrumentation commonly used for trajectory data are photographic instrumentation with fixed pre-determined fields of view (MTP 4-2-816), cinetheodolites or tracking cameras (MTP 5-1-0314), and radars and velocimeters (MTP 4-1-0055). Telemeter data are frequently used on complex systems to monitor in-flight operating characteristics (motor pressure, fuze arming, guidance commands, etc.).

NOTE: The type of photographic instrumentation used to obtain the trajectory data acquisition depends on the type data desired and the characteristics of the test item. If the test item is sufficiently physically large or has a low velocity, cinetheodolites can be used to obtain the trajectory data. If the item has a high velocity or is too small to be tracked with cinetheodolites, fixed position cameras properly oriented and operated during the firing sequence are used to obtain position data at the desired points along the trajectory. A multitude of fixed orientation cameras would be necessary to obtain frequent position data. For this reason, the use of such instrumentation is often limited to coverage of the launch and the area of motor burnout and warhead event.

j. Temperature-condition each rocket or missile at specified temperatures for at least 24 hours before firing, or as required to achieve temperature stabilization, in order to obtain consistent firing data. Each rocket or missile shall be transported from the temperature-conditioning chamber to the test site in the specified shipping container or locally provided containers to assure minimum temperature loss between the time the round is removed from the conditioning chamber and the time it is fired.

3.2 Data Required. Record the following:

a. Nomenclature, serial number, accuracy tolerances, calibration requirements, and last date test equipment was calibrated

b. Nomenclature, serial number(s), and manufacturer's name of the test item(s); only one lot of each type component shall be used.

c. Test component data, including:

(1) Overall length of complete round with fuze in pre-flight and in-flight configuration
(2) Total weight of complete round with fuze
(3) Bourrelet diameters at points 90° apart
(4) Center of gravity of complete round, measured from nose end of the test item
(5) Center of gravity of the burnout round, measured from nose end of the test item
(6) Weight of motor propellant charge
(7) Transverse and axial moments of inertia of representative rounds, in before-firing and after-firing conditions
(8) Type, size, and location of fins
(9) Miscellaneous information pertinent to the round that might affect its ballistic characteristics (e.g., propellant configuration, nozzle cant, fin pitch, head filler)
(10) Expected muzzle velocity
(11) Expected range and height of burst
(12) Expected burnout time, velocity, and locaton
(13) Expected exit time from ignition
(14) Expected time to cargo ejection (event)
(15) Expected range to cargo impact

d. Manufacturing defects and damage to the test item(s) incurred during transit

4. <u>TEST PROCEDURES</u>. For all firings on a given occasion, as little time as possible should elapse between firings. No firings should take place when surface wind velocity is a head or tail wind (±30°) exceeding 24 km/hr (15 mph). For all other wind directions, no firings should take place if wind speeds exceed 16 km/hr (10 mph).

4.1 <u>Single Fire</u>.

a. Tactically emplace the test firing launcher in a precisely surveyed position on the firing range, and record launcher coordinates.

b. Measure and record the actual height of the trunnions of the emplaced launcher or the centerline of the launcher tube above the ground in relation to sea level. NOTE: This measurement is required for accurate location of impact data and to provide a reference point for photographic measurements.

c. Emplace the photographic and electronic instrumentation in precisely surveyed positions in accordance with MTP 3-2-8216 and MTP 4-2-816. Additional instrumentation may be required in special cases. Record coordinates of each measuring instrument (velocimeter, photosonic camera, cinetheodolite, etc.). All instrumentation must be emplaced in such a manner that it is protected from blast and shock of firing, as well as unexpected warhead detonation near launch if explosive warheads are used.

d. Connect a range time code generator and an electrical sequencer to all camera stations, the velocimeter recording system, and the firing launcher.

e. Apply test equipment power, and calibrate the entire instrumentation system as a unit.

f. Load the test item in the launcher and establish the firing elevation of the launcher using a calibrated gunner's quadrant. When applicable, set appropriate time to event into rocket warhead, check time with applicable calibration equipment. Electrical connectors on launcher must be cleaned after each firing, unless indicated otherwise in technical manuals.

g. Lay the launcher on the previously determined firing azimuth using a surveyor's transit, and start the instrumentation sequence timer.

h. Continue the countdown and at "time zero", fire the weapon.

i. Acquire the rocket or missile with the tracking instrumentation, and track until the impact point is reached. Record data until the end of flight of the rocket or missile.

j. Obtain warhead event and impact coordinates with range instruments, time of flight, and order of warhead function, if applicable.

k. Repeat steps e through i above, as necessary to obtain the required data or to resolve incongruities.

l. Measure and record prevailing meteorological conditions (surface and aloft) before and during testing. Measure surface wind direction and velocity at the firing position at the time each round is fired.

4.2 Ripple Firings.

a. Tactically emplace the multiple-tube firing rocket launcher in a precisely surveyed position on the firing range, and record launcher coordinates.

b. Repeat step b of 4.1. Replace the range observer's azimuth instruments, previously used to measure the impact coordinates, with time-related framing cameras aimed for purposes of triangulation at the expected impact area (horizontal pictures).

c. Station a helicopter with an aerial camera (framing) immediately above the impact area (but out of danger).

d. Load the multiple-tube launcher with test samples, and establish the elevation of the launcher using a calibrated gunner's quadrant. Follow procedures of para 4.1.f.

e. Lay the launcher on the previously determined firing azimuth using a surveyor's transit, and start all instrumentation.

f. Start countdown and fire the weapon at "time zero".

g. Operate the aerial camera and other required instrumentation during the ripple firing and when all rounds are striking in the target area.

h. Repeat steps d, e, f, and g above, as necessary to obtain the required data or to resolve incongruities.

i. Repeat 4.1.1 for ripple firings.

5. DATA REQUIRED. Record the following data, in addition to specific instructions for each subtest:

a. Time and date of firing
b. Launcher tube firing elevation angle, before and after each firing
c Firing azimuth of launcher
d. Altitude of launcher trunnions
e. Altitude of impact area
f. Launcher motion during firing
g. Coordinates of the various impacts, including any submunitions, as well as warhead event (in accordance with TOP 3-2-8257)
h. Meteorological conditions at launch site and to maximum ordinate of round and in impact area if a submunition round
i. Launcher coordinates
j. Coordinates of each measuring instrument (velocimeter, camera, etc.)
k. Photographs or motion pictures, radiographs, sketches, maps, charts, graphs, r other pictorial or graphic presentations which will support test results or conclusions
l. An engineering log book containing pertinent remarks and observations in chronological order which would aid in a subsequent analysis of the test data. This information may consist of a description of equipment or components, and functions and deficiencies as well as theoretical estimations, mathematical calculations, test condition, intermittent or catastrophic failures, test parameters, etc., that were obtained during test.
m. Instrumentation or measurement system mean error stated accuracy
n. Test item sample size (number of measurement repetitions)
o. Fuze set time, dud rate, time of flight, identification of each warhead event and impact with a specific sample point

5.1 Single Fire. Record the following:

a. Ignition delay time (time from application of firing pulse to motor ignition)
b. Time of first motion of test sample
c. Time to "launch" (launch is when the test sample is free of launcher constraint)
d. Time of flight of sample
e. Velocity and acceleration versus time, from "launch" to beyond test sample motor burnout
f. Time-position history from muzzle to or beyond burnout
g. Spin history
h. Velocity at the muzzle of the launcher or as close to the muzzle as practical
i. Time of motor burnout
j. Tip off in vertical and horizontal planes

5.2 Ripple Firings. In addition to the required impact coordinate data, record times of flight for the longest and shortest rounds fired.

6. DATA REDUCTION AND PRESENTATION.

Event-timing shall be determined from the multi-channel oscillograph recording. Tip-off angle, acceleration on the launcher, and launcher reactions shall be determined from the high-speed (2000-5000 frames per second) cameras. Yaw, pitch, roll, space position, velocity, and accelerations shall be obtained from the fixed and tracking cameras beneath and beside the trajectory, in conjunction with the velocimeter data. The range time code recorded on the velocimeter magnetic tape and the photographic films make possible to correlate observations from the cameras with the velocimeter records. Film records shall be measured on precision comparators, and the linear displacements of the images from the apparent optic axis established. By combining these data with the radar information, computations will provide the continuous vector or tangential velocity versus time along the entire trajectory. This information is usually presented in graphical form. Compute position coordinates as a function of time, and present in tabular form.

A written report shall accompany all test data and shall consist of conclusions and recommendations drawn from test results. The test engineer's opinion concerning the success or failure of any of the functions evaluated, shall be included. In addition, equipment specifications that will serve as the model for a comparison of the actual test results should be included.

Equipment evaluation usually will be limited to comparing the actual test results to the equipment specifications and the requirements as imposed by the intended usage. The results may also be compared to data gathered from previous tests of similar equipment.

Recommended changes of this publication should be forwarded to Commander, US Army Test and Evaluation Command, ATTN: AMSTE-AD-M, Aberdeen Proving Ground, MD 21005-5055. Technical information can be obtained from the preparing activity: Commander, US Army Combat Systems Test Activity, ATTN: STECS-AD-A, Aberdeen Proving Ground, MD 21005-5059. Additional copies are available from the Defense Technical Information Center, Cameron Station, Alexandria, VA 22304-6145. This document is identified by the accession number (AD No.) printed on the first page.

APPENDIX A

REFERENCES

1. MTP 4-2-816, Photographic Instrumentation for Trajectory Data, 28 December 1966.

2. MTP 3-2-801, Measurement of Internal Diameters of Cannon, 27 October 1965.

3. TOP 3-2-802, Measurements of Cannon, 9 August 1976.

4. MTP 5-1-031, Cinetheodolites, 31 March 1969.

5. MTP 4-1-005, The Doppler Velocimeter, 30 April 1970.

6. MTP 3-2-821, Ballistic Data for Boosted Projectiles, 28 December 1966.

7. TOP 3-2-825, Location of Impact or Airburst Positions, 2 November 1976.